CLAIMS

1. A regulating device comprising a balance (1) and a plane hairspring (2) for a time piece movement, the plane hairspring (2) including in its outer turn (7) a stiffened portion (8) arranged to cause the deformations of the turns to be substantially concentric, characterized in that the spacing (d) between a terminal portion of the outer turn (7) and the last-but-one turn (9) of the hairspring (2) is large enough for said last-but-one turn (9) to remain free radially during expansions of the hairspring (2) up to amplitudes corresponding substantially to the maximum angle of rotation of the balance (1) in said movement.

2. A regulating device according to claim 1, characterized in that the maximum angle of rotation of the balance (1) in said movement is slightly less than the knocking angle.

3. A regulating device according to claim 1 or claim 2, characterized in that the maximum angle of rotation of the balance (1) in said movement is substantially equal to 330°.

4. A regulating device according to any one of claims 1 to 3, characterized in that the spacing (d) between the terminal portion of the outer turn (7) and the last-but-one turn (9) of the hairspring (2) is large enough for said last-but-one turn (9) to remain free radially during expansions of the hairspring (2) up to amplitudes corresponding substantially to the knocking angle of the balance (1) in said movement.

5. A regulating device according to any one of claims 1 to 4, characterized in that the stiffened portion (8) is a portion of strip of thickness (e) in the plane of the

hairspring (2) greater than the thickness (e_0) of the remainder of the strip forming the hairspring (2).

6. A regulating device according to claim 5, characterized in that the thickness (e) in the plane of the hairspring (2) of the stiffened portion (8) varies over the entire length of the stiffened portion (8) as a convex and continuous function and presents a minimum substantially equal to the thickness (e_0) of the remainder of the strip at the two ends of the stiffened portion (8) and a maximum that is greater than the thickness (e_0) of the remainder of the strip between said two ends.

7. A regulating device according to claim 5, characterized in that the thickness (e) in the plane of the hairspring of the stiffened portion (8") is substantially constant over the entire length of said stiffened portion (8").

8. A regulating device according to claim 5, characterized in that the thickness (e) in the plane of the hairspring (2) of the stiffened portion (8''') is substantially constant over the entire length of said stiffened portion (8''') except in terminal portions (13) where, respectively, the thickness (e) decreases continuously towards the ends (14) of said stiffened portion (8''').

9. A regulating device according to any one of claims 5 to 8, characterized in that the extra thickness defined by the stiffened portion (8) relative to the remainder of the strip is situated exclusively on the outer side of the outer turn (7).

10. A regulating device according to any one of claims 5 to 9, characterized in that the height of the hairspring

is substantially constant over the entire length of said hairspring.

11. A time piece movement including a regulating device according to any one of claims 1 to 10.

12. A time piece, such as a watch, including a movement according to claim 11.

13. A method of designing a regulating device having a balance (1) and a plane hairspring (2) for a time piece movement, in which method a stiffened portion (8) is provided in the outer turn (7) of the plane hairspring (2) so as to cause the deformations of the turns to be substantially concentric, the method being characterized in that a spacing (d) is also provided between a terminal portion of the outer turn (7) and the last-but-one turn (9) of the hairspring (2), said spacing (d) being large enough for said last-but-one turn (9) to remain free radially during expansions of the hairspring (2) up to amplitudes corresponding substantially to the maximum angle of rotation of the balance (1) in said movement.

14. A method according to claim 13, characterized in that in order to design the plane hairspring (2) with the stiffened portion (8"), the following steps are performed:

- defining a plane hairspring of constant strip thickness;
- determining the unbalance of said plane hairspring;
- determining a portion of the outer turn of said plane hairspring having the same unbalance as the plane hairspring; and
- stiffening said outer turn portion.

15. A method according to claim 14, characterized in that the step of stiffening the outer turn portion consists in increasing its thickness (e) in the plane of the hairspring (2).

16. A method according to claim 13, characterized in that in order to design the plane hairspring (2) with the stiffened portion (8), the following steps are performed:

· defining a plane hairspring of constant strip section;

· determining the unbalance of said plane hairspring;

· determining a portion of the outer turn of said plane hairspring having the same unbalance as the plane hairspring; and

· varying the thickness (e), in the plane of the hairspring, of the strip forming the hairspring between an angle δ_1 and an angle δ_2 such that $\delta_1 < \beta_1$ and $\delta_2 > \beta_2$, where $\beta_2 - \beta_1$ is the angular extent of said portion of the outer turn, the thickness being caused to vary in accordance with a predetermined function f presenting a minimum substantially equal to the thickness (e_0) of the remainder of the strip at the angles δ_1 and δ_2, the function f and the angles δ_1 and δ_2 being selected so that the deformation of the turn portion delimited by the angles δ_1 and δ_2 is substantially the same as the deformation which would occur if the thickness of the strip between the angles δ_1 and β_1 and between the angles β_2 and δ_2 were the same as that of the remainder of the hairspring and if, between the angles β_1 and β_2, the stiffness of the outer turn were equal to a predetermined value, greater than that of the remainder of the strip.

17. A method according to claim 16, characterized in that said predetermined value is infinite.

18. A method according to claim 16 or claim 17, characterized in that the predetermined function f is convex and continuous.

19. A method according to any one of claims 13 to 18, characterized in that in order to determine a spacing (d) that is sufficient between the terminal portion of the outer turn (7) and the last-but-one turn (9), the following steps are implemented:

· defining a first point (P_1) on the radial axis passing through the outer end (P_0) of an initial plane hairspring having a stiffened portion (8), the first point (P_1) being situated beyond the last-but-one turn of said initial plane hairspring when said last-but-one turn is expanded by an amplitude corresponding to the maximum angle of rotation of the balance;

· defining a second point (P_2) on the outer turn;

· interconnecting the first and second points (P_1, P_2) by a circular arc (18) that is tangential to the outer turn at the second point (P_2);

· defining a third point (P_3) on the circular arc (18) between the first and second points (P_1, P_2), the third point (P_3) being such that the length of the segment of the circular arc (18) delimited by the second and third points (P_2, P_3) is equal to the length of the initial turn segment (19) delimited by the second point (P_2) and the initial outer end (P_0) of the hairspring; and

· giving a thickness in the plane of the hairspring to the circular arc (18) between the second and third points (P_2, P_3) that is identical to the thickness of the initial turn segment (19), the resulting turn segment between the second and third points (P_2, P_3) constituting a corrected terminal portion of the outer turn.

20. A method according to claim 19, characterized in that the second point (P_2) is situated at the end of the

stiffened portion that is further from the outer end of the hairspring.

21. A method according to any one of claims 13 to 18, characterized in that in order to determine a spacing that is sufficient between the terminal portion of the outer turn (7') and the last-but-one turn (9'), the following steps are implemented:

· defining a point on the outer turn in the stiffened portion;

· offsetting the terminal portion of the hairspring extending from said point radially outwards by giving the inner side of said terminal portion a circularly-arcuate shape the center of which is the geometrical center (O) of the hairspring and the outer side of said terminal portion a shape that gives said terminal portion a thickness in the plane of the hairspring that is identical to the thickness of the corresponding initial terminal portion of the outer turn; and

· connecting the terminal portion with the remainder of the stiffened portion by a connection portion that forms a double bend (11).

22. A method of making a regulating device having a balance and a plane hairspring for a time piece movement, consisting in designing the regulating device in accordance with the method as defined in any one of claims 13 to 21, and then fabricating said regulating device.